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THE NORTH AMERICAN MUCORALES—I

Family MUCORACEAE

DAVID ROSS SUMSTINE

INTRODUCTION

The Mucoraceae have attracted the attention of botanists for more than two hundred years and from the number of papers and theses published on the subject in Europe recently the interest remains unabated.

The American species have never been studied systematically, although local and state lists of fungi contain the names of the more common species. Pound* describes the American genera and enumerates a few species. The splendid work of Blakeslee† deals entirely with zygospore formation.

The synonymy is exceedingly complicated and the status of many described species cannot be definitely determined. Lendner‡ reports seventeen imperfectly described species in the genus *Mucor* appearing from 1884 to 1906. The rule of priority has frequently been ignored and the same name has been used for different species. Fischer§ has unraveled the intricate synonymy of the European species.

Dried specimens soon lose their taxonomic characters, and therefore herbarium material, even when available, is seldom satisfactory for the exact determination of the specimens. The viability of the spores is lost in three to ten months and consequently cultures cannot be made from old material in order to establish the true identity of the specimens.

While this paper is intended primarily to enumerate only species seen and examined by the writer, yet, for the purpose of giving a better survey of the American species, a few have been admitted on the authority cited under Species Reported.

* Minn. Bot. Studies 1: 87-104. 1894.

† Proc. Am. Acad. 40: 205-319. 1904.

‡ Les Mucorinees de la Suisse 100. 1908.

§ Rabenh. Krypt. Fl. 1892.

At the conclusion of these studies, my own material will be placed in the Carnegie Museum, Pittsburgh, and in the New York Botanical Garden. This will be done in the hope that other mycological workers who are not directly connected with large public institutions will also deposit their material in institutions where it will be available to future students.

I am indebted to Dr. W_M. Holland, of the Carnegie Museum, Pittsburgh, for assistance in making collecting trips in Pennsylvania. My thanks are especially due to Dr. N. L. Britton for the opportunity of examining the specimens in the herbarium and consulting the literature in the library of the New York Botanical Garden. The various members of the staff of the Garden have very kindly and cheerfully rendered valuable service in the preparation of this paper.

Order MUCORALES

Saprophytic or parasitic fungi with well-developed mycelium, the mycelium branched and unicellular. Reproduction sexual (zygospores) and asexual (spores produced in sporangia or conidia produced singly or in chains).

Schroeter* recognizes five families, *Mucoraceae*, *Mortierellaceae*, *Choanophoraceae*, *Chaetocladiaceae*, and *Piptocephalidaceae*. The total number of species for the whole world is less than 150. Most of these are described from Europe.

Family MUCORACEAE

Asexual reproduction by spores in sporangia with columella or sometimes in sporangioles without columella. Sexual reproduction by zygospores formed on the mycelium or on aerial filaments by the union of two copulating branches (gametes).

KEY TO THE GENERA

1. *Simplices*

Sporangiophores simple, unbranched.

Sporangiophores arising from stolons, sporangial membrane not cuticularized.

Sporangiophores arising from the nodes of the stolons.

1. MUCOR.

Sporangiophores arising from the internodes of the stolons.

2. ABSIDIA.

* Pflanzenfamilien 1¹: 123. 1892.

Sporangiophores arising from the mycelium, sporangial membrane not cuticularized.

Sporangiophores long, with metallic luster. 3. PHYCOMYCES.

Sporangiophores variable in length, white, gray, brown. 4. HYDROPHORA.

Sporangiophores brown or brownish with spiny aërial filaments. 5. SPINELLUS.

Sporangiophores arising from the mycelium or from mycelial swelling, sporangial membrane cuticularized.

Sporangiophores arising from mycelial swellings. 6. HYDROGERA.

Sporangiophores not as above. 7. PILAIRA.

2. *Ramosi*

Sporangiophores variously branched.

Sporangiophores dichotomously branched. 8. SYZYGITES.

Sporangiophores without terminal sporangia, branches circinate. 9. CIRCINELLA.

Sporangiophores with terminal sporangia, branches with sporangioles.

Sporangioles on dichotomous branches. 10. THAMNIDIUM.

Sporangioles on circinate branches. 12. HELICOSTYLUM.

Sporangioles on straight branches, arising from bulbs. 11. BULBOTHAMNIDIUM.

Sporangiophores with sporangia only.

Branches long or short, zygosporangia with nearly equal suspensors. 13. CALYPTROMYCES.

Branches as above, zygosporangia on dichotomous branches, suspensors unequal. 14. ZYGORHYNCHUS.

I. MUCOR (Mich.) L., Sp. Pl. 1185. 1753

Ascophora Tode, Fung. Meckl. 1: 13. 1790.

Type species, *Ascophora Mucedo* Tode.

Rhizopus Ehrenb. Nov. Acta Acad. Leopold 10¹: 198. 1820.

Type species, *Rhizopus nigricans* Ehrenb.

ORIGINAL DESCRIPTION: Fungus vesicula subrotunda, in qua semina numerosa affixa, receptaculis criniformibus constans.

Type species, *Mucor Mucedo* L.

Sporangiophores simple, usually growing in clusters of two, three, or five from the nodes of the stolons, enlarged below the sporangia forming an apophysis; mycelium white at first, then brown, growing by stolons attached at different places to the substratum by rhizoids; zygosporangia borne on the mycelium, naked.

Robert Hooke (*Micrographia* 125, *pl. 12, f. 1.* 1665) describes and figures a mushroom growing on "divers kinds of putrefied bodies, such as skin raw or dressed, flesh, blood, milk, green cheese, rotten sappy wood, or herbs, leaves, bark, roots of plants." The plants were also found "to bespeck and whiten over the red covers of a small book bound in sheep skin. This kind of leather gathers mould more easily than other leathers."

The plants are described as long, cylindrical with transparent stalks bending over with the weight of a round knob that grows on the top of them. The illustrations might easily be our common black mould but the habitat makes it somewhat doubtful.

Malpighius (*De Plant. in aliis Veg.* 65, *pl. 28, f. 108.* 1687), describes and figures accurately the so-called *Mucor stolonifer*. He observed the plants "*in Cucurbitae putrescente pericarpio.*" He observed clearly the rhizoids, *radicibus minimis*, and the clusters of sporangiophores arising from the nodes of the stolons "sometimes five, sometimes three, and not rarely two." His description and discussion leave no doubt as to the identity of his plants (see Wilson, *Bull. Torrey Club* 33: 557. 1906).

Micheli *l. c.* first establishes the genus *Mucor* and divides it into two sections, *Mucores pediculo donati* and *Mucores pediculo-carentes*. The first species enumerated is *Mucor vulgaris* and characterized as follows, "*capitula lucida per maturitatem nigra, pediculo griseo.*" He cites Malpighius, Hooke and Sterbeeck. The brief description and the illustration are not conclusive as to the identity of his species but when studied in connection with his observations, it is very evident that he had before him *Mucor stolonifer*.

In the *Species Plantarum*, Linnaeus enumerates under the genus *Mucor* eleven species but only one, *Mucor Mucedo*, is now retained under the genus, which becomes the type of the genus. He cites *Mucor vulgaris* of Micheli as a synonym. Without doubt, *Mucor vulgaris* and *Mucor Mucedo* refer to the same plant. A careful study of the above citations leaves no doubt as to the identity of the plants of Malpighius, Micheli and Linnaeus.

The following citations may be given as additional or corroborative evidence that the early botanists had before them the *Mucor Mucedo* of Linnaeus with the identity as above indicated:

Gleditsch (Meth. Fung. 158 seq. 1753) describes a number of *Mucors* among which is *M. vulgaris*. He cites Micheli, Malpighius and Linnaeus. Haller (Hist. Stirp. Helv. 3: 113. 1768) lists *Mucor Mucedo* growing on bread. Batsch (Elench. Fung. 157. 1783) enumerates and describes six *Mucors*. The first one is *Mucor Mucedo*. Fries (Syst. Myc. 3: 310. 1829) lists *Ascophora Mucedo* but gives as synonym *Mucor Mucedo*, *Auct. pro parte*. The description fits very clearly the species under consideration.

These various names were applied to the plant of Linnaeus until 1850, when Fresenius (Beitr. Myk. 4-13. pl. I, f. 1-12. 1850) described and figured quite a different plant under the name *Mucor Mucedo*. His plant was no other than *Hydrophora stereocorea* Tode (see under *Hydrophora*), and quite distinct from *Mucor Mucedo* L. But since the time of Fresenius many authors have considered *Mucor Mucedo* L. and *Mucor Mucedo* Fres. synonymous, although the plants described by these two men are very different.

Zimmerman (Das Genus *Mucor* 4. 1870) recognized the real identity of *Mucor Mucedo*. He says that the description and figure of Malpighius undoubtedly refer to *Mucor stolonifer* Ehrenberg but he ignores the *Mucor Mucedo* of Linnaeus.

KEY TO THE SPECIES

- | | |
|--|-------------------------|
| Rhizoids abundant, at the nodes of the stolons, spores large, irregular. | 1. <i>M. Mucedo</i> . |
| Rhizoids few, short, spores smaller, oval or round. | 2. <i>M. arrhizus</i> . |
| Rhizoids few, sporangiophores with swellings. | 3. <i>M. nodosus</i> . |

I. MUCOR MUCEDO L. Sp Pl. 1185. 1753. Not *Mucor Mucedo* Fres.

Ascophora Mucedo Tode, l. c. 1790.

Mucor stolonifer Ehrenb. l. c. 1818.

Rhizopus nigricans Ehrenb. l. c. 1820.

Mucor ascophorus Link, Willd. Sp. Plant. 6¹: 85. 1824.

See Fischer l. c. for further synonymy.

This is the common black mould of bread and of decaying vegetable matter. The shape and the size of the spores are exceedingly variable.

SUBSTRATA: On bread, pumpkin, squash, sweet potato, fruits.

SPECIMENS EXAMINED: Delaware, *Cummins*; Kansas, *Fung. Columb. 1673*; Kingston, Jamaica, *Ellis Collection 66*; New Jersey, *Ellis Collection 1628*; New York, *Underwood and Cook 89*; Nebraska, *Pound*; Pennsylvania, *Sumstine*; South Carolina, *Ravenel 622, 89*; Washington, D. C., *Galloway*.

ILLUSTRATIONS: Malpighius, *l. c. pl. 28, f. 108, e, f, g*; Corda, *Icon Fung. 1: pl. 11, f. 78, pl. 12, f. 83*; Link, *Ges. Naturf. Freunde Berl. Mag. 3: pl. 2, f. 43*; Fischer, *l. c. f. 39*.

2. *MUCOR ARRHZIZUS* (Fischer) Hagem, Norweg. Mucorineen
37. 1908

Rhizopus arrhizus Fischer, *l. c. 233. 1892.*

The stolons are less developed than in the preceding species; the sporangiophores grow from the nodes in umbels or corymbs; the spores are round or oval, irregular, angular.

SUBSTRATA: On bread.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Hagem, *l. c.*

3. *Mucor nodosus* (Namysl.).

Rhizopus nodosus Namysl. Bull. Acad. Sci. Cracovie. 1906.

(This paper was not available.)

The few rhizoids, the branching sporangiophores, the somewhat flattened columella, and the peculiar nodes or swellings in the sporangiophores characterize this species.

SUBSTRATA: On sterilized bread.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Lendner, *l. c. 122.*

SPECIES REPORTED

Mucor rhizopodiformis Cohn, Zeitschr. f. Klinische Medicin 7: 148. 1884. *Rhizopus Cohnii* Berlese & de Toni; Sacc. Syll. Fung. 7: 213. 1888.

No. 1950 in the Ellis Collection is labeled *Rhizopus Cohnii*. The plants were found growing "in kraut barrel attached to sides." The spores are small and regular in form. Attempts to germinate some of the spores were unsuccessful. The species is considered pathogenic in dogs and rabbits.

DOUBTFUL SEPCIES

Mucor inaequalis Peck, Ann. Rep. N. Y. State Mus. 26: 79. 1874.

2. ABSIDIA Van Tieghem, Ann. Sci. Nat. VI. 4: 350.

1876

ORIGINAL DESCRIPTION: En résumé, les *Absidia* sont caractérisés vis-à-vis de toutes les autres Mucorinées: 1° par le développement de leur appareil sporangial en arcades paraboliques, issus l'une de l'autre en sympode et couronnées chacune par un bouquet de sporanges piriformes; 2° par les rameaux verticillés, cuticularisés et colorés, qui viennent envelopper et protéger la zygospore.

Ces caractères placent ce genre entre le *Rhizopus* et le *Phycomyces*, mais plus près du premier. (In part.)

Type species, *Absidia capillata* Van Tieghem.

Sporangiophores in groups of 2-5, developed from the internodes of the stolons, terminated by a pear-shaped sporangium with columella; zygospores produced on the stolons, enveloped by circinate, cuticularized filamentous threads growing from the suspensors.

1. ABSIDIA SPINOSA Lendner, Mucor. Suisse

132. 1908

? *Absidia cylindrospora* Hagem, Unters. Norweg. Mucor. 45. 1908.

Lendner gave a preliminary description of this species in Bull. de l'Herb. Boissier II, 7: No. 3. 1907. The spine growing from the extremity of the columella suggested the name *spinosa*.

SUBSTRATA: Grown in the laboratory on sterilized bread.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine* (laboratory culture).

ILLUSTRATION: Lendner, l. c. f. 46.

3. PHYCOMYCES Kunze, Myk. Hefte 2: 113. 1823

ORIGINAL DESCRIPTION: Flocci decumbentes, continui, simplices, flaccidi. Sporidia oblonga circa vesiculam pyriformem apice insidentem collecta.

Type species, *Ulva nitens* Agardh, Syn. Alg. Scand. 46. 1817.

Sporangiophores erect, simple, terminated by a large sporangium, growing singly from the mycelium; zygospores borne on the mycelium, suspensors with dichotomously branched outgrowths, copulating branches tong-shaped.

1. PHYCOMYCES NITENS (Agardh) Kunze, *l. c.* 1823

Ulva nitens Agardh, *l. c.* 1817.

Periconia phycomyces Bonord. Hbdk. Allg. Myk. 113. 1851.

Mucor romanus Carnoy, Bull. Soc. Royal Bot. Belg. 9: 157. 1870.

Mucor violaceus Bref. Bot. Unters. 4: 56, 92. 1881.

The large, metallic-like sporangiophores enable one to identify this species even without lens or microscope. It prefers oily or greasy substances and can easily be grown on ground flax seed. It has been reported as growing on a mushroom, *Collybia dryophilila* (Bull.) Fr. (Peck, Ann. Rep. N. Y. State Mus. 31. 1909).

SUBSTRATA: On ground flax seed, cornmeal, horse manure.

SPECIMENS EXAMINED: North Carolina, *Wood*; New York, *Mrs. N. L. Britton*; Oregon, *Lake*; Pennsylvania, *Sumstine*, *Schweinitz*.

ILLUSTRATIONS: Carnoy, *l. c.* *pl. 1, f. 1-4, pl. 2, f. 1-3, pl. 3, f. 1-7*; Van Tieghem, Ann. Sci. Nat. V. 17: *pl. 20*; Bainier, Étude, *pl. 1, f. 12-15*.

4. HYDROPHORA Tode, Fung. Meckl. 2: 5. 1791

Mucor (Mich.) L. (Many authors since 1850.)

ORIGINAL DESCRIPTION: Fungus globosus, stipitatus, capitulo aqueo; stipite capillari subrecto; fructificatione ignota.

Type species, *Hydrophora stercorea* Tode.

Sporangiophores simple, arising singly from the mycelium, terminated by a sporangium with columella; zygospores borne on the mycelium, naked, copulating branches straight. The species under Section I. Mono-Mucor, of Fischer (Rabenh. Krypt. Fl. 1⁴: 184. 1892), belong to this genus.

Under this genus, Tode placed three species, *H. minima*,* *tenella*,† *stercorea*. The descriptions of the first and second are

* Fischer (Rabenh. Krypt. Fl. 1⁴: 297) thinks this is a *Syncephalis*, probably *S. nodosa*.

† See under *Pilaira* for further discussion.

too indefinite for exact determination. The characterization of the third species seems to agree with the plants now usually passing under the name *Mucor Mucedo* L. Tode found his plants on human dung but he also discovered some plants on dog dung which agree in every way with the former except in size.

There may be some doubt as to the absolute identity of Tode's plants but authors generally have cited his name as a synonym of the so-called *Mucor Mucedo* L. It is, at least, the oldest name given to dung inhabiting Mucors with simple sporangiophores unless some one can prove that Haller's species, *Lycogola petiolatum*, *aquosum*, *flavescens*, is a *Mucor* (Haller, Hist. Stirp. Helv. 3: 112. 1768).

KEY TO THE SPECIES

Sporangiophores erect.

Columella cylindric or somewhat globose.

1. *H. stercorea*.

Columella pear-shaped.

2. *H. Fischeri*.

Sporangiophores flaccid, decumbent.

Sporangia and sporangiophores brownish or yellow-brown.

3. *H. Taeniae*.

Sporangia and sporangiophores yellow or refusecent.

4. *H. rufescens*.

1. *HYDROPHORA STERCOREA* Tode, *l. c.* 1791

? *Mucor caninus* Pers. Obs. Myc. 1: 96. 1796.

Mucor stercoreus Link, Willd. Sp. Pl. 6¹: 90. 1824.

Mucor Mucedo Fres. Beitr. Myc. 7. 1850. Not *Mucor Mucedo* L.

Mucor Mucedo L. (Many authors since 1850.)

This plant varies considerably in the size of the sporangia and the spores but the shape of the spores is rather constant. I have not found branching sporangiophores although they have been reported (Lendner, Mucor. Suisse 68. 1908). The species is also considered pathogenic (Neveu-Lemaire Precis de Parasitologie humaine. 1906).

SUBSTRATA: On human and horse dung.

SPECIMENS EXAMINED: Indiana, *Arthur*; New Jersey, *Ellis N. A. F.* 972; Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Fres. *l. c.* pl. 1, f. 1-12; Fischer, Rabenh. Krypt. Fl. 1⁴: f. 30-31.

2. *Hydrophora Fischeri* nom. nov.

Mucor piriformis Fischer, *l. c.* 191. 1892.

Not *Mucor pyriformis* Leers, Fl. Herborn. 288. 1789.

It is unfortunate that Fischer's name had been used before and therefore must be reduced to synonymy. The pear-shaped columella suggested the name given by Fischer.

The specimens referred to this species have a smaller columella and larger spores than those given in the original description (see Torrey 9: 143. 1909).

SUBSTRATA: On dung of deer.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Fischer, *l. c. f.* 30 c.

3. *Hydrophora Taeniae* (Fairman).

Mucor Taeniae Fairman, Proc. Roch. Acad. Sci. 533. 1891.

The author of this interesting species gives the following description, "Sporangiferous hyphae erect, rarely if ever branched septate, yellow, 7μ diam.

"Sporangia globose, brownish or yellow brown, smooth, mostly 40μ in diam. Columella elliptical or sub-sphaeroidal, at times with contraction at the base, brownish.

"Spores globose, or ellipsoid, light yellow, $3-5\mu$ in diam. with smooth episore. Zygosporoes not observed."

SUBSTRATA: On segments or joints of tape worm (*Taenia solium*).

SPECIMENS EXAMINED: New York, *Fairman*.

ILLUSTRATIONS: Fairman, *l. c. pl.* 4, *f.* 4-6.

4. *Hydrophora rufescens* (Fischer).

Mucor rufescens Fischer, *l. c.* 192. 1892.

Mucor rubens Vuillemin, Bull. Soc. Myc. Fr. 3: 111. 1887.

Vuillemin's description is incomplete but in all probability he had the same plant before him as Fischer. The latter author cites *Mucor rubens* as a synonym of his species.

The sporangiophores are very flaccid and form a network over the substratum.

SUBSTRATA: On elephant dung.

SPECIMENS EXAMINED: New York, *Sumstine*.

SPECIES REPORTED

Mucor mucilagineus Bref. Bot. Unters. 4: 58. 1881.

This species has been reported from Michigan by Kauffman (Ann Rep., Mich. Acad. Sc. 8: 28. 1905). The author appends a note as follows, "Probably a variety of the type from which it differs slightly. On decaying fungi."

5. SPINELLUS Van Tieghem, Ann Sci. Nat. VI. 1:

66. 1875

ORIGINAL DESCRIPTION: Par leur mycélium aérien, dont les filaments se cuticularisent, brunissent et se couvrent de petits rameaux épineux, par leur tube fructifère également cuticularisé et coloré en brun foncé, y compris la columelle qui s'insère au-dessus du point d'attache du sporange sur le filament, par leurs spores noirâtres, enfin par la courbure en mors de pince des deux rameaux renflés qui se conjuguent pour former la zygospore, ces deux espèces se distinguent de tous les *Mucor* à moi connus et doivent former un genre distinct, qui vient se placer entre le *Phycomyces* et le *Rhizopus*, non loin du *Sporodinia*. Son nom, *Spinellus*, est tiré des petites épines qui hérissent les filaments mycéliens et dont le développement est lié au mode de nutrition et au parasitisme de ces plantes.

Type species, *Mucor fusiger* Link=*Mucor rhombosporus* Ehrenb.

Sporangiophores erect, simple, brown or yellowish-brown, with thorny, branched aerial filaments bearing the zygospores.

KEY TO THE SPECIES

- | | |
|--|-----------------------------|
| Spores narrowly ellipsoid with obtuse or rounded ends. | 1. <i>S. rhombosporus</i> . |
| Spores broadly ellipsoid with acute ends. | 2. <i>S. macrocarpus</i> . |

1. SPINELLUS RHOMBOSPORUS (Ehrenb.) Pound, Minn. Bot.

Studies 1: 96. 1894

Mucor rhombosporus Ehrenb. Syll. Myc. Berol. 25. 1818.

Mucor fusiger Link, Verh. Naturf. Freunde Berl. Mag. 1: 108. 1820.

Spinellus fusiger Van Tieghem, l. c. 1875.

This species grows on agarics, especially species of *Mycena*. The aerial filaments with thorny branches and the spores with obtuse ends distinguish it.

Ehrenberg described the species first as *Mucor rhombosporus*

but later says that he made a mistake in the examination of the spores. Link suggested verbally to him the name *Mucor fusiger* which Ehrenberg prefers and accepts but according to the rules of priority the former name must be retained.

SUBSTRATA: On decaying agarics.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Van Tieghem, *l. c. pl. 1, f. 29-37*; Bainier, *Étude, pl. 3, f. 1-13*.

2. *SPINELLUS MACROCARPUS* (Corda) Karst., *Myc. Fenn.* 4: 73.
1878

Mucor macrocarpus Corda, *l. c. Fung.* 2: 21. 1838.

This species differs from the other chiefly in spore character as shown in the key.

SUBSTRATA: On decaying agarics.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

ILLUSTRATION: Corda, *l. c. pl. 12, f. 84*.

6. *HYDROGERA* Web. and Wigg., *Prim. Fl. Holsat.* 110.
1780.

Pilobolus Tode, *Schrift. Gesell. Naturf. Freunde Berl.* 5: 46.
1784.

Type species, *Pilobolus crystallinus* (Web. and Wigg.) Tode.

ORIGINAL DESCRIPTION: Capsula humido aquoso repleta, pileo hemisphaerico tecta.

Type species, *Hydrogera crystallina* Web. and Wigg.

Sporangiophores simple, erect or oblique, colorless or with orange colored contents, arising from swellings in the mycelium and ending with ellipsoid swellings beneath the sporangium; sporangia lenticular, with columella, membrane cuticularized above but disappearing in the lower half; zygospores borne on the mycelium, naked, with tong-shaped copulating branches.

KEY TO THE SPECIES

Spores elliptic.

Spores small, $3-6 \times 6-10 \mu$.

Spores variable, larger, $6-10 \times 12-20 \mu$.

Spores ellipsoid or nearly globose, $10-12 \times 12-14 \mu$.

Spores globose, variable in size.

1. *H. obliqua*.

2. *H. Kleinii*.

3. *H. longipes*.

4. *H. Oedipus*.

1. HYDROGERA OBLIQUA (Scop.) O. Kuntze, Rev. Gen. Pl.

2: 855. 1891

Mucor obliquus Scop., Fl. Carn. 2: 494. 1772.*Hydrogera crystallina* Web. and Wigg., l. c. 1780.*Pilobolus crystallinus* (Web. and Wigg.) Tode, l. c. 1784.? *Mucor urceolatus* Dicks., Pl. Crypt. Brit. 1: 25. 1785.

Scopoli gives a good description of this species and Weber and Wiggers cite his species as follows, "*Mucor obliquus* Scop. Carn. n. 1643 cum nostra convenit." Tode bases his genus on *Hydrogera crystallina* and cites as a synonym *Mucor obliquus*.

The sporangium rests somewhat on the side of the subsporangial swelling. The mycelial swelling is buried in the substratum.

SUBSTRATA: On dung of horse.

SPECIMENS EXAMINED: Pennsylvania *Ellis & Ev. N. A. F. 831, Sumstine*; New York, *Sumstine*.

ILLUSTRATIONS: Tode, l. c. pl. f. 1-7; Link, Ges. Naturf. Freunde Berl. Mag. 3: pl. 2, f. 49-50; Bull. Herb. Fr. pl. 480, f. 1.

2. HYDROGERA KLEINII (Van Tieghem) O. Kuntze, l. c. 1891

Pilobolus Kleinii Van Tieghem, Ann. Sc. Nat. VI. 4: 337. 1876.

This species is nearest *H. obliqua* but may be distinguished by the form of the spores, by the mycelial swelling, and by the smaller sporangiophores.

SUBSTRATA: On horse dung.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Van Tieghem, l. c. pl. 10, f. 6-10.

3. HYDROGERA LONGIPES (Van Tieghem) O. Kuntze, l. c. 1891

Pilobolus longipes Van Tieghem, l. c. 6, 4: 338. 1876.*Pilobolus roridus* Bref. Bot. Unters. 4: 70. 1881.

This species is possibly mistaken for one of the other species and therefore has not been previously reported for America. The long swelling at the base of the sporangiophore and the elliptic-spherical spores are determinative characters.

SUBSTRATA: On horse dung.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*; New York, *Sumstine*.

ILLUSTRATIONS: Van Tieghem, *l. c. pl. 10, f. 10-15*; Bref. *l. c. pl. 4, f. 17*; Bainier, *Étude, pl. 2, f. 11-12*.

4. *HYDROGERA OEDIPUS* (Mont.) O. Kuntze, *l. c.* 1891
Pilobolus Oedipus Mont. Mem. Soc. Linn. de Lyons 1. 1826.
 (The original description was not seen by me.)

This species may be known by the rather short sporangiophores and the globose spores of unequal size.

SUBSTRATA: On dung of horse.

SPECIMENS EXAMINED: The following collections are in the Herbarium of the New York Botanical Garden but only the ejected sporangia caught on paper and on leaves are found in the packets and therefore the determinations were made from spore characters only.

Canada, *Ellis*; Kansas, *Kellerman*; Louisiana, *Langlois*; Nebraska, *Williams*; Pennsylvania, *Meehan*, *Rothrock*, *Scribner*.

ILLUSTRATIONS: Bainier, *Étude, pl. 2, f. 1-10*.

SPECIES REPORTED

Hydrogera rorida O. Kuntze, *l. c.* 1891. *Mucor roridus* Bolt. Hist. Fung. 3: 168. 1789. *Pilobolus roridus* Pers. Syn. Fung. 117. 1801.

This species is reported by Pound in Minn. Bot. Studies 1: 101. 1894.

7. *PILAIRA* Van Tieghem, Ann. Sci. Nat. VI. 1:

51. 1875

ORIGINAL DESCRIPTION: Les deux caractères que nous venons d'assigner au genre *Pilobolus*, à savoir la déhiscence spéciale du sporange, déterminée par la structure même de cet organe, et sa projection, liée au contraire à la forme et à la structure du filament qui le porte, sont, avons-nous dit, indépendants l'un de l'autre. On conçoit donc que le premier puisse exister sans le second, et c'est précisément ce qui a lieu dans le genre nouveau que nous allons étudier maintenant. Le sporange y possède la même structure, et par conséquent le même mode de déhiscen-

ce que chez les *Pilobolus*; mais il n'est pas projeté dans l'atmosphère, et à cette absence de projection correspond naturellement l'absence de la structure et de la forme si caractéristiques du filament sporangifère qui déterminent ce phénomène les *Pilobolus*. . . . C'est de cette faculté de soulever son sporange au lieu de le projeter que j'ai tiré le nom générique *Pilaira*, par opposition à celui de *Pilobolus*.

Type species, *Pilaira Cesatii* Van Tieghem = *Pilobolus anomalus* Cesati.

This genus is chiefly distinguished from *Hydrogera* by the absence of mycelial and subsporangial swellings.

Fischer (Rabenh. Krypt. Fl. 1⁴: 257) cites *Hydrophora tenella* Tode as a synonym of *Pilaira nigrescens* Van Tieghem. If the synonymy of these two species could be established, then the genus *Pilaira* would become a synonym of *Hydrophora* with *H. tenella* as the type of the latter genus. This would change the conception of the genus *Hydrophora*. The lack of type specimens and the very brief diagnosis of *Hydrophora tenella* do not justify such a conclusion. The genus of Van Tieghem therefore stands.

I. PILAIRA FIMETARIA (Link) Pound, Minn. Bot. Studies 1: 100.
1894

Mucor fimetarius Link, Ges. Naturf. Freunde Berl. Mag. 3: 30.
1809. Berl. Mag. Gesell. Naturf. Freunde.

Pilobolus anomalus Cesati, Bot. Zeit. 9: 647. 1851.

Hydrophora fimetaria Fries, Syst. Myc. 3: 313. 1829.

Ascophora Cesatii Coemans, Acad. Roy. Sci. Belg. 30: 63. 1861.

Pilaira Cesatii Van Tieghem, Ann. Sci. Nat. VI. 1: 51. 1875.

Link's name is evidently the oldest that can with any certainty be applied to this species.

The sporangia are black when mature, columella depressed globose, spores oval or elliptic oval. The zygospores are borne on tongue-shaped copulating branches.

SUBSTRATA: On decoction of manure.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*. (In laboratory cultures.)

ILLUSTRATIONS: Van Tieghem, l. c. pl. 1, f. 14-24; Coemans, l. c. pl. 2, f. e.

8. SYZYGITES Ehrenb. Syll. Myc. Berol. 25. 1818

Sporodinia Link, Willd. Sp. Pl. 6¹: 94. 1824.

Type species, *Sporodinia grandis* Link.

? *Azygites* Moug. et Fries; Fries, Syst. Orb. Veg. 1: 364. 1825.

ORIGINAL DESCRIPTION: Hic fungus est verus *Mucor erectus*, *Aspergillo* maximo simillimus, simul vero est vera conjugata. Ab *Aspergillo* recedit vesicis lateralibus binis in corpus fusiforme connascentibus. Moventur semina.

Type species, *Syzygites megalocarpus* Ehrenb.

Sporangiophores erect, septate, repeatedly dichotomously branched, terminated by a sporangium with columella; zygospores on special, upright, dichotomously branched filaments.

Link bases his new genus *Sporodinia* on *Aspergillus globosus* Link (Obs. 1: 14. f. 15. 1809). There is no such species given on page 14 but on page 16, figure 15 is cited under the name *Aspergillus maximus*. The figure is very clearly the species under consideration.

The genus *Azygites* is not clear.

1. SYZYGITES ASPERGILLUS (Scop.) Pound, Minn. Bot. Studies
1: 96. 1894

? *Mucor ramosissimus* Haller, Hist. Stirp. Helv. 3: No. 2167. 1768.

Mucor aspergillus Scop. Fl. Carn. 2: 494. 1772.

Mucor ramosus Bull. Hist. Champ. Fr. 116. 1791.

Mucor flavidus, Pers. Obs. Myc. 1: 95. 1796.

Mucor rufus Pers. Syn. Fung. 200. 1801.

Aspergillus maximus Link, l. c. 1809.

Syzygites megalocarpus Ehrenb. l. c. 1818.

? *Monilia spongiosa* Pers. Myc. Europ. 1: 30. 1822.

Sporodinia grandis Link, l. c. 1824.

Mucor capitato-ramosus Schw. Trans. Am. Phil. Soc. II. 4: 285. 1832.

Sporodinia dichotoma Corda, Ic. Fung. 1: 22. 1837.

? *Nematogonium fumosum* Bonord. Hdbk. Allg. Myk. 116. 1851.

? *Nematogonium simplex* Bonord. Hdbk. Allg. Myk. 117. 1851.

Mucor dichotomus Bref. Bot. Unters. 4: 95. 1881.

Sporodinia aspergillus Schroet. Syll. Fung. 7: 207. 1887.

This species has been frequently described by different authors, as the above synonyms indicate. The name *Syzygites* was given to the zygospor-bearing mycelium while the name *Sporodinia* was applied to the part producing the sporangia.

If the identity of Haller's plant were absolutely sure, his name would have to be substituted for the name given above.

This reddish-brown mould is easily recognized and very generally found on decaying *Boleti* and other fungi.

SUBSTRATA: On decaying agarics, *Boleti*, *Polyperi*.

SPECIMENS EXAMINED: Canada, *Anderson* 622; Maryland, *Fung. Columb.* 1494; Massachusetts, *Farlow* 1487; New Jersey, *Ellis* 2279; Pennsylvania, *Sumstine*; Virginia, *Murrill*.

ILLUSTRATIONS: *Bull. l. c. pl.* 480, *f.* 3; *Pers. l. c. pl.* 6, *f.* 5; *Bref. l. c. pl.* 6, *f.* 23-25; *Bainier, Étude, pl.* 4, *f.* 1-10.

9. *CIRCINELLA* Van Tieghem & Le Monnier, *Ann. Sci.*
Nat. V. 17: 298. 1872

ORIGINAL DESCRIPTION: Le filament fructifère est recourbé en crosse au-dessous du sporange qui est ainsi réfléchi vers le bas. . . . En outre, le développement de leur appareil fructifère aérien est indéterminé, et, comme les *Rhizopus* et *Chaetocladium*, elles végétent en guirlandes à la manière des Lianes.

Le sporange, ainsi réfléchi le long du filament qui le porte, est de forme sphérique, et muni d'une grande columelle cylindro-conique; sa membrane est incrustée de granules d'oxalate de chaux, non diffuente, et à la maturité elle se déchire circulairement vers son milieu, en laissant une large cupule hémisphérique autour de la base de la columelle pour laisser échapper un grand nombre de petites spores sphériques. (In part.)

Type species, *Circinella umbellata* Van Tieghem et Le Monnier.

Sporangiophores growing singly from the mycelium, not terminated by a sporangium, with lateral, fascicled or single, circinate branches terminated by a sporangium with columella; zygospor borne on distinct sporangiferous filaments.

I. *CIRCINELLA UMBELLATA* Van Tieghem & Le Monnier, *l. c.* 300.
1872

Mucor umbellatus Schroet. *Krypt. Fl. Schles.* 3: 206. 1886.

The clusters of sporangia on the principal sporangiophores enable one to identify this species.

SUBSTRATA: On dung of lion, horse, jaguar.

SPECIMENS EXAMINED: New York, *Sumstine*; Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Van Tieghem & Le Monnier, *l. c. pl. 21, f. 18-23*; Bainier, *Etude, pl. 6, f. 1-7*; Bainier, *Bull. Soc. Myc. Fr. pl. 7, f. 10*.

10. THAMNIDIUM Link, Ges. Naturf. Freunde
Berl. Mag. 3: 31. 1809

ORIGINAL DESCRIPTION: Sporangium globosum. Stipes tubulosus, septatus, basi ramosissimus, ramorum apicibus sporidia nuda sustentantibus. Hoc genere series quae a Mucedinibus incipiebat, iterum ad Mucedines redit. Sporangium mucoris, peridio tenuissimo, aqua adfusa rumpente et sporidia majuscula, globosa effundente.

Stipes Mucedinum basi quoque in ramis dichotomis vera Mucedinum sporidia nuda profert, ita ut revera ambigua sit planta.

Type species, *Thamnidium elegans* Link.

Sporangiophores erect, terminated by a sporangium, with several dichotomously divided branches; the terminal sporangia many spored with columella; sporangioles on the dichotomous branches with few spores and without columella; zygospores formed on the mycelium, naked, copulating branches straight.

1. THAMNIDIUM ELEGANS Link, *l. c.* 1809

Melidium subterraneum Eschweiler, De Fruc. Gen. Rhiz. 33.
1822.

Mucor elegans Fries, Syst. Myc. 3: 322. 1829.

Ascophora elegans Corda, Ic. Fung. 3: 14. 1839.

This beautiful species is easily recognized by the two kinds of sporangia and by the dichotomous branches. It is seldom reported from this country.

Bachmann (Bot. Zeit. 107. 1895) describes six different typical forms cultivated on different substrata.

SUBSTRATA: On dung of tiger and horse.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Link, *l. c. pl. 2, f. 45*; Eschweiler, *l. c. pl. f. 10*; Corda, *l. c. pl. 2, f. 43*; Bref. Bot. Unters. 9: *pl. 2, f. 1-8*; Bainier, *Étude, pl. 8, f. 1-5*; Nees, *Sys. der Pilze, pl. 6, f. 75*.

II. *BULBOTHAMNIDIUM* Klein, Verh. Zool.-bot. Ges. Wien
20: 557. 1870

Chaetostylum Van Tieghem & Le Monnier, Ann. Sc. Nat. V. 17:
328. 1873.

Type species, *Chaetostylum Fresenii* Van Tieghem & Le Monnier.

ORIGINAL DESCRIPTION: Die aufrechte Fruchthyphye zeigt bei *Bulbothamnidium* unterhalb der Spitze eine unregelmässig kugelige oder ellipsoidische Anschwellung, aus welcher rundherum viele Seitenzweige zweiter Ordnung entspringen, die abermals unter der Spitze eine Anschwellung zeigen, aus welcher erst viele kurze Zweige 3. Ordnung entspringen und die kugeligen Sporangiolen tragen. Ausser dieser Grundform finden sich noch einige Modificationen derselben und zwar kommt es vor, dass die Haupthyphye keine Anschwellung zeigt, sondern dass die Seitenzweige zweiter Ordnung wirtelig als gewöhnliche Verzweigungen entstehen, und sich dann im Uebrigen ebenso verhalten, wie im ersten Fall. Weiter findet man Haupthyphen mit mehreren Anschwellungen über einander, diese aber sind einseitig, aus denselben entspringen wieder viele Seitenzweige zweiter Ordnung, welche unter der Spitze eine allseitige Anschwellung zeigen, aus welcher dann, wie im ersten Fall die kurzen Sporangiolen tragenden Zweige dritter Ordnung ausgehen. Die Anschwellung kann auch an den Aesten zweiter Ordnung nur einseitig sein, wie es in Fig. 17 bei *b* zu sehen ist, während gleich über dieser Stelle noch eine allseitig Anschwellung zu finden ist.

Type species, *Bulbothamnidium elegans* Klein = *Ascophora pulchra* Preuss.

Sporangiophores erect, terminated by a sporangium with columella, with numerous side branches terminated by sterile ends; sporangiferous branches springing from swellings or bulbs, sporangioles without columella; zygospores unknown.

1. *Bulbothamnidium pulchrum* (Preuss).

Mucor Mucedo Fres. Beitr. zur Myk. 96. 1860. (In part.)

Ascophora pulchra Preuss, Linnaea 24: 139. 1851.

Bulbothamnidium elegans Klein, l. c. 1870.

Chaetostylum Fresenii Van Tieghem & Le Monnier, l. c. 1873.

Thamnidium chaetocladioides Bref. Bot. Unters. 4: 57, 58. 1881.

Thamnidium Fresenii Schroet. Krypt. Fl. Schles. 3: 210. 1886.

The branches growing from swellings on the principal sporangiophores are very characteristic of the genus and the species. My specimens have longer branches than the measurements given in the various descriptions cited but otherwise they agree.

SUBSTRATA: On decaying *Polyporus* among other moulds.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Fresenius, l. c. pl. 12, f. 13-16; Van Tieghem & Le Monnier, l. c. pl. 23, f. 61-63; Brefeld, l. c. pl. 2, f. 5; *idem*. 9: pl. 2, f. 9-18; Bainier, Étude, pl. 7, f. 1-7.

2. *Bulbothamnidium pulchrum variabile* var. nov.

On a piece of beef kept in a refrigerator at a temperature of 40° Fahr. there appeared a dense growth of mould in the autumn of 1908. A careful examination failed to identify it. The sporangiophores were simple, unbranched, 5-15 mm. high, white to grayish white; sporangia large, gray with a greenish hue, spherical; columella cylindrical with collarette; spores elliptical, 6-12 μ , often larger in the same sporangium. The material was set aside and marked new species.

A year later the same plants growing under similar conditions were again found. From this material cultures were made on sterilized bread. The culture proved very perplexing; instead of a simple sporangiophore, there appeared branched sporangiophores as in *Bulbothamnidium pulchrum*. In all, sixteen cultures were made and exactly the same result was obtained in each culture. Ordinary beef (not sterilized) was then inoculated with spores from the original plants and kept at a temperature of about 40° Fahr. The simple sporangiophores were produced in these cultures.

The mode of branching, the shape and the size of sporangium, columella and spores agree fairly well with *Bulbothamnidium pulchrum* and therefore I do not feel justified at present in describing it as a new species. The variability in the form of the sporangiophores on different substrata and under different conditions seems to merit a new form.

SUBSTRATA: On beef and sterilized bread.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

Diagnosis: Hyphae sporangiferae simplices, non ramosae, erectae, candidae, 5–15 mm. altae; sporangia magna, candida, viridi-flava, sphaerica; columella cylindrica; spores variae in magnitudine, ellipticae, 6–12 μ .

Hab. In bubula.

12. *HELICOSOTYLUM* Corda, Icon. Fung. 5: 18, 55. 1842

ORIGINAL DESCRIPTION: Hyphasma decumbens, ramosum, continuum. Stipes erectus spiraliter incurvatus, simplex, continuus, dein deciduus. Sporangium acrogenum, membranaceum, stipite adfixum dein deciduum, rumpens. Columella nulla. Spores irregulariter conglobatae continuae, episporio simplici, nucleo firmo, guttulis oleosis repleto.

Type species, *Helicostylum elegans* Corda.

Sporangiophores erect or decumbent, terminated by a sporangium with a columella; branches spirally and irregularly arranged along the sporangiophores, terminated by a sporangium without columella. The zygospores are unknown.

SPECIES REPORTED

1. *Helicostylum cyaneum* Pound and Clements, Bot. Survey Neb. 4: 5. 1896.

13. *CALYPTROMYCES* Karst. Bot. Zeit. 20: 365. 1849

Pleurocystis Bonord. Hdbk. Allgemein. Myk. 124. 1851.

Type species, *Pleurocystis Fresenii* Bonord. = *Mucor racemosus* Fres.

Chlamydomucor Bref. Bot. Unters. 8: 228. 1890.

Type species, *Mucor racemosus* Fres.

ORIGINAL DESCRIPTION: Peridiola globosa, membranacea, circumscissa, in floccis terminalia, nucleos centrales, persistentes, sporidiaque includentia. Sporidia subglosa discreta. Flocci tubulosi, erecti, septati ramosi vel simplices. Thallus ramosus, vesiculis, farctus vel cellulosus.

Type species, *Calyptromyces ramosus* Karst.

Karsten was the first to establish a separate genus for branching Mucors. Two new species are described under this genus,

Calyptromyces ramosus and *simplex*. The former is well described and figured. He also describes and illustrates the germination of the spores and the chlamydospores.

Bonorden described a genus for short-branched Mucors. Five species are listed under the genus. The first, *Pleurocystis ascendens*, is described and figured as new. This may be an abnormal form of the Karsten species. *Pleurocystis fungicola*, which is the same as *Ascophora fungicola* Corda, is probably referable to *Calyptromyces ramosus*. *Pleurocystis Helicostylum* and *Candelabrum* are placed under other genera. This still leaves *Pleurocystis Fresenii*, which Bonorden says is synonymous with *Mucor racemosus* Fres.

This complex group contains some forty described species but the relationship of these species is not well known. There seem to be two modes of branching, monopodial and sympodial. This branching has been made the basis for the division into two groups, Racemo-Mucor and Cymo-Mucor (see Fischer, *l. c.* and Lendner, *l. c.*). This division, however, is uncertain and unsatisfactory.

A number of the species produce in addition to the zygosporcs, azygosporcs. Of the species referred to this genus by European authors 6 produce azygosporcs, 6 zygosporcs only and in 29 neither zygosporcs nor azygosporcs have been observed. Of the 12 species whose zygosporcs or azygosporcs are known, eight belong to the section Racemo-Mucor. Of the 4 remaining species, one is imperfectly described and the branching not definitely known, one is closely allied to the genus *Circinella*, one has zygosporcs closely resembling azygosporcs, and one is described as monopodially and sympodially branched.

Vuillemin has established a new genus (see *Zygorhynchus*) for two species of this section. The formation of the zygosporcs is the basis for the separation.

When the zygosporic or the azygosporic characters of the 29 remaining species are known some of them may be referred to the genus *Calyptromyces*, others to the genus *Zygorhynchus*, and others may have sufficient differences to justify the establishment of a new genus or even new genera.

Cultures in known media will in all probability aid in deter-

mining the line of cleavage between genera as well as between species.

The azygospores indicate a tendency to eliminate the sexual method of reproduction. Investigation along this line may aid in solving some problems in the evolution of plants and possibly determine more clearly the phylogeny of the Mucoraceae.

In more than one half of the species there are also developed oïdiospores and chlamydospores. These may have some taxonomic value when they are more clearly understood.

The limits of this genus are possibly best left undetermined for the present except as defined in the original description. It seems that most of the species listed in Section 2, *Racemo-Mucor*, by Fischer *l. c.* and Lendner *l. c.* should be placed in this genus.

KEY TO THE SPECIES

| | |
|--|-------------------------------|
| Sporangiophores with short, straight or very slightly bent branches. | 1. <i>C. ramosus</i> . |
| Sporangiophores with rather short circinate branches. | 2. <i>C. circinelloides</i> . |
| Sporangiophores with usually long branches. | |
| Columella globose or nearly so. | 3. <i>C. erectus</i> . |
| Columella piriform with spines. | 4. <i>C. plumbeus</i> . |
| Columella piriform without spines. | 5. <i>C. globosus</i> . |

I. CALYPTROMYCES RAMOSUS Karst. *l. c.* 1849

? *Mucor juglandis* Link, Ges. Naturf. Freunde Berl. Mag. 3: 30. 1809.

? *Mucor truncorum* Link, Ges. Naturf. Freunde Berl. Mag. 3: 30. 1809.

Mucor racemosus Fres. *l. c.* 1850.

Pleurocystis Fresenii Bonord. *l. c.* 1851.

Chlamydomucor racemosus Bref. *l. c.* 1890.

Link describes two branching *Mucors* that seem to agree with the species under consideration but it is impossible to say definitely that his plants are identical with Karsten's plants. If these plants are the same then Link's name would have to be substituted for the name given above.

The height of the sporangiophores varies from 5–50 mm. The branches are usually short and straight. The columella may be globose or oval. The spores globose or elliptical. The chlamydospores and oïdiospores are very numerous. Both zygosporos and azygosporos have been observed.

SUBSTRATA: On bread, mule dung, potato.

SPECIMENS EXAMINED: New York, Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Karst. *l. c. pl. 6*; Fres. *l. c. pl. 1*; Fischer, *l. c. f. 30*.

2. *Calyptromyces circinelloides* (Van Tieghem).

Mucor circinelloides Van Tieghem, Ann. Sci. Nat. VI. 1: 94.

1875

The branches are circinate but all terminate with a sporangium. This species seems to connect with the genus *Circinella*. Fischer *l. c.* 205 describes the zygospores.

SUBSTRATA: On bread.

SPECIMENS EXAMINED: New York, Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Bainier, *l. c. pl. 7, f. 9-15*; Hagem, Unters. Norweg. Mucor. 1: 36.

3. *Calyptromyces erectus* (Bainier).

Mucor erectus Bainier, Ann. Sci. Nat. VI. 19: 207. 1884.

This species differs from the preceding by the longer branches, by the elliptic and unequal spores. Zygospores and azygospores have been observed (see Bainier, *l. c.*).

SUBSTRATA: On ground flaxseed.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

4. *Calyptromyces plumbeus* (Bonord.).

Mucor plumbeus Bonord. Abh. Naturf. Ges. Halle 8: 109. 1864.

Mucor spinosus Van Tieghem, Ann. Sci. Nat. VI. 4: 390. 1876.

The spines growing on the top of the columella are very characteristic of this species. The only other species known to have a spinescent columella is *Mucor spinescens* Lendner. The latter differs from the former in the smaller sporangiophores.

SUBSTRATA: On beef broth, bread.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Fischer, *l. c. f. 30 e*; Bainier, *l. c. pl. 7, f. 1-8*.

5. *Calyptromyces globosus* (Fischer).

Mucor glöbosus Fischer, *l. c.* 202. 1892.

This species was found by Walter Kerr, a student in the Pittsburgh High School, by exposing boiled potatoes for *Mucor* spores.

The specimens agree very well with Fischer's description except in the shape of the columella. This is given as piriform but my specimens have variously shaped columellas, piriform, obovate, panduriform. The sporangia are globose, at first greenish-yellow, at maturity brown to black.

SUBSTRATA: On boiled potato, sterilized bread.

SPECIMENS EXAMINED: Pennsylvania, Kerr, Sumstine.

SPECIES REPORTED

1. *Mucor ambiguus* Vuillemin, Bull. Soc. Nancy 92. 1886.

This species is reported by Kauffman (Ann. Rep. Mich. Acad. Sci. 8: 28. 1905). It was found on mummied plums.

14. ZYGORHYNCHUS Vuillemin, Soc. Myc. Fr. 19:

114, 115, 116. 1903

ORIGINAL DESCRIPTION: Filaments du thalle continus, ramifiés, inégaux, parfois noueux, plongeants, rampants ou formant un-duvet aérien cotonneux. Chlamydospores lisses, intercalaires ou terminales. Pédicelles isolés ou groupés sur des systèmes sympodiques irréguliers qui portent des sporocystes normaux, des sporocystes abortifs et des zygosporos. Pas d'apophyse. Sporocystes uniformes, à membrane plus ou moins concrescente avec la base de la columelle, plus ou moins incrustée d'oxalate de calcium, plus ou moins diffuse. Quand la membrane est fugace, elle laisse à la base une collerette. Spores nombreuses, petites lisses. Zygosporos fortement hérissées, rostrées. Tympanes d'insertion subopposés, inégaux, le plus petit au sommet du rostre. Suspenseurs inégaux et dissemblables, le petit droit et court, le grand long, courbe, termine par un renflement piriforme. Gametes très inégaux. L'appareil zygosporé naît sur un système de filaments aériens, comme les sporocystes.

Type species, *Mucor heterogamus* Vuillemin.

The development of the zygosporos from unlike and unequal copulating branches characterizes this genus.

1. ZYGORHYNCHUS MOELLERI Vuillemin, l. c. 117. 1903

Mucor Moelleri Lendner, Mucor. Suisse 72, 1908.

The type species of the genus has not been found since its

first discovery in 1886. This second species was found in 1902. It differs principally in the smaller elliptic spores, smaller zygo-spores, and depressed columella. Azygospores and chlamydo-spores are rather abundant.

SUBSTRATA: On sterilized bread.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*. (Only in laboratory cultures.)

ILLUSTRATIONS: Lendner, *l. c.* f. 25.

ADDITIONAL GENERA

The following genera have been established somewhat recently by European authors but no species of these genera have yet been reported for America. An enumeration of these genera may interest students of the American Mucoraceae.

1. *Pirella* Bainier, Ann. Sci. Nat. VI. 15: 84. 1882.

Type species, *Pirella circinans* Bainier.

The zygo-spores are unknown. It is very near the genus *Circinella*.

2. *Dicranophora* Schroet. Jahresb. Schles. Ges. Vaterl. Cultur. 64: 198. 1886. (Not available.)

Type species, *Dicranophora fulva* Schroet.

This species has been found only by Schroeter, on *Paxillus involutus*.

It may be recognized by the principal sporangia with central columella and numerous spores and by the sporangioles on dichotomous branches with forked columella and few spores. The zygo-spores have very unequal suspensors.

3. *Tieghemella* Berlese & De Toni; Sacc. Syll. Fung. 7: 215. 1888.

Type species, *Absidia repens* Van Tieghem.

The zygo-spores are unknown.

4. *Mycocladus* Beauverie, Ann. de Univer. de Lyon 162-180. 1900.

Type species, *Mycocladus verticillatus* Beauverie.

This has been placed by Lendner in the genus *Absidia* although the zygo-spores do not have the cuticularized threads or filaments.

5. *Proabsidia* Vuillemin, Bull. Soc. Myc. Fr. 19: 116. 1903.

Type species, *Mucor Saccardoii* Oudemans.

The zygospores have the characters of the genus *Absidia*.

6. *Lichtheimia* Vuillemin, Bull. Soc. Myc. Fr. **19**: 126. 1903.

Type species, *Mucor corymbifer* Cohn.

The zygospores have not been observed.

7. *Parasitella* Bainier, Bull. Soc. Myc. Fr. **19**: 153. 1903.

Type species, *Parasitella simplex* Bainier = *Mucor parasiticus* Bainier.

The specific name has been changed in the transfer to the new genus. The zygospores are not known.

8. *Glomerula* Bainier, Bull. Soc. Myc. Fr. **19**: 154. 1903.

Type species, *Glomerula repens* Bainier.

From the description and figure, this seems very different from the other known *Mucors*.

9. *Pseudo-Absidia* Bainier, Bull. Soc. Myc. Fr. **19**: 155. 1903.

Type species, *Absidia dubia* Bainier.

The specific name is changed to *Pseudo-Absidia vulgaris* Bainier. This is generally referred to the genus *Absidia*.

THE SCHWEINITZ COLLECTION OF MUCORS

In his Synopsis of North American Fungi, Schweinitz lists under the genus *Mucor* seventeen species, Nos. 2726-2742, as follows, *Mucor fimetarius*, *rufus*, *flavidus*, *Mucedo*, *ascophorus*, *tenuis*, *carneus*, *minimus*, *tenellus*, *caninus*, *stercoreus*, *murinus*, *Fimbria*, *albo-virens*, *truncorum*, *capitato-ramosus*, *echinophila*; under *Thamnidium*, one species, No. 2743, *Thamnidium elegans*; under *Pilobolus*, two species, Nos. 2227-2228, *Pilobolus crystallinus*, *roridus*.

All these numbers are missing in the Herbarium of the Academy of Sciences, Philadelphia, and therefore further consideration is out of the question.

There are some unnumbered packets in this herbarium that belong to the Schweinitz collection. The specimens were presumably collected by him. The following is a list of these specimens with my notes.

1. *Mucor rufus*. No specimen in the packet but the label reads "*Mucor rufus* in *Boleto*." This was probably *Syzygites aspergillus*.

2. *Mucor minimus*. The name *tenellus* also appears on the

label but has been crossed out. There is nothing on the substratum to indicate the presence of a *Mucor*.

3. *Mucor tenuis*. The packet contains small pieces of discolored wood.

4. *Mucor albo-virens*. No specimen in the packet.

5. *Mucor caninus*. No specimen in the packet but inside the packet is written "*Mucor stercoreus*, Beth., *Aspergillus flavus*, Salem."

6. *Mucor Fimbria*. Packet empty.

7. *Mucor ascophorus*. No specimen in the packet but an additional label reads, "*Ascophora Mucedo*."

8. *Mucor truncorum*. Only a few stems (sporangiophores ?) were found. Impossible to identify.

9. *Mucor capitato-ramosus*. This was a new species. A remnant of the host, possibly a *Polyporus*, was the only thing found in the packet. See under *Syzygites aspergillus*.

10. *Mucor echinophila*. This is also described as a new species. The specimens are all gone and the identity is uncertain. The description is brief and inadequate. See Schweinitz, *l. c.* No. 2742.

11. *Syzygites megalocarpus*. The packet is empty, but in all probability he had *Syzygites aspergillus*.

12. *Phycomyces nitens*. A few sporangiophores clearly indicate this species.

13. *Thamnidium elegans*. Not this species, whatever it is. The material is too scanty for identification.

14. *Pilobolus crystallinus*. The packet contains some dried manure but there is no evidence of this species.

THE BERKELEY AND CURTIS SPECIES

In Grevillea 3: 148-149, the following new species are described from America by Berkeley and Curtis:

1. *Mucor paradoxus*. This plant was collected by Michener in Pennsylvania on decaying *Boletus*. "The Flocci are short, hyaline, the vesicles (sporangia) of two kinds, the larger globose on longer flocci, the smaller obovate but narrow on short pedicels springing from the mycelium."

In Sacc. Syll. Fung. 7: 211, this is placed under the genus

Thamnidium by Berlese and De Toni. From the description, it is impossible to tell where it belongs.

2. *Mucor Cucurbitarum*. This was collected in South Carolina by Ravenel and in New England by Sprague, on decaying gourds and melons. The habitat and the description point to the common *Mucor Mucedo*.

3. *Mucor Beaumontii*. Beaumont collected this species in Alabama on decaying cabbage leaves. The spores are said to be dark purple, otherwise it may be referred to *Mucor Mucedo*.

4. *Mucor curtus*. This was found on decaying muskmelon in South Carolina. The spores are "fusiform with a minute appendage at either end, binucleate, .00057 long, about $\frac{2}{3}$ as much wide." This is surely not a *Mucor*.

5. *Ascophora fusca*. This species was described in the Journal of the Linnaean Society 10: 363. 1868. It was collected in Cuba on fruit of *Atrocarpus*. The sporangia are described as "*globosis dein collapsis umbraculiformibus*." The collapsed, umbrella-shaped columella indicates *Mucor Mucedo*, or some species of this genus.

STATE LISTS OF FUNGI

In addition to the references and citations already made, the following lists of fungi were consulted but specimens of the species enumerated in these lists were not examined by the writer and therefore they are not included in the present paper.

ALABAMA: Underwood and Earle, Preliminary List of Alabama Fungi. 1897.

CALIFORNIA: Harkness and Moore, Catalogue of the Pacific Coast Fungi. 1880.

CUBA: Ramon de la Sagra, Icones Plantarum in Flora Cubana Descriptarum. 1863.

GREENLAND: Rostrup, Fungi Groenlandiae. 1888.

MASSACHUSETTS: Tuckerman and Frost, A Catalogue of Plants growing without cultivation within thirty miles of Amherst College. 1875.—Farlow, Bulletin of the Bussey Institute. 1876.

MAINE: Ricker, A Preliminary List of Maine Fungi. 1902.

NORTH CAROLINA: Curtis, Geological and Natural History Survey of North Carolina. Part 3. Botany. 1867.

OHIO: Kellerman and Werner, Catalogue of Ohio Plants. Geology of Ohio. 1895.

PENNSYLVANIA: Herbst, Fungal Flora of Lehigh Valley. 1899.

WEST VIRGINIA: Millspaugh and Nuttall, Flora of West Virginia. 1896.

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